Case Report

Piezopuncture-Assisted Canine Distalization in Orthodontic Patients: Two Case Reports

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ABSTRACT

With the increasing number of young adults seeking orthodontic treatment to improve their smile esthetics or oral function, the time spent wearing brackets is one of the biggest challenges for these patients. Various surgical techniques have been developed over the years to accelerate tooth movement and reduce the total treatment time. A newly introduced, minimally invasive procedure namely piezopuncture, which uses a piezosurgical tool to create multiple cortical punctures through the gingiva, is presented in this report of two extraction cases.

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Introduction

Recently, the number of adult patients seeking orthodontic treatment to improve their dentofacial esthetics or oral functions has increased. [1] These patients usually want their treatment duration to be as short as possible to reduce the undesirable impacts of orthodontic appliances on their social lives. Currently, the length of orthodontic treatment with fixed braces can averagely range from one to three years, which is frustrating for many patients. [1-2] Furthermore, prolonged orthodontic treatment may be associated with more enamel decalcifications, gingival recession or root resorption. [3-4] Therefore, over years, various attempts have been made to accelerate tooth movement and shorten the treatment period. These attempts can be classified into three following groups. The first group is local or systemic use of certain biochemicals such as interleukins, vitamin D, and prostaglandins. [5-7] The second group is physical or mechanical stimulation of alveolar bone, which includes the use of magnets and electromagnetic fields, direct electrical current and low-energy laser. [8-11] The third group includes surgical interventions on periodontal tissues such as undermining interseptal bone (dento-alveolar distraction) and alveolar corticotomies. [12-13]

Wilcko brothers added bone grafting to corticotomies to increase periodontal support in special cases. [14-15] Corticision was introduces by Kim *et al.* as an alternative approach for corticotomy procedures. [16-17] In this flapless technique, incisions are made directly through the gingiva and bone using a combination of reinforced scalpel and a surgical mallet. [16] However, repetitive hammering appears to be rather aggressive and causes fear and discomfort for patients. In 2009, Dibart *et al.* [18] suggested a new minimally invasive technique called piezicision, which uses a piezoelectric knife to produce the bony cuts in the buccal cortex and initiate the regional acceleratory phenomenon (RAP) effect.

In 2013, Kim YS *et al.* proposed a novel procedure for cortical activation called Piezopuncture. [19] Instead of using a piezosurgical scalpel, they used a piezotome, an ultrasonic tool, to develop multiple cortical punctures through the gingiva. This minimally invasive procedure significantly accelerated tooth movements and anabolic activity in dogs. [19] The effect of piezopuncture on the rate and type of tooth movement in human being has not been reported prev-

Figure 1: Case1, pretreatment extraoral photographs

iously. For the first time, in this case report, the application of piezopuncture technique to assist canine distalization in two orthodontic patients is presented.

Case Report 1

A 28-year-old male patient presented at the orthodontic clinic of Mashhad University of Medical Sciences with chief complaint of upper anterior crowding and an unpleasant smile. Usual diagnostic evaluations including impressions, intraoral and facial photographs, panoramic and lateral cephalometric tracing were performed. Extraoral examination showed a symmetric face with normal vertical facial height and a convex profile. The lips were competent at rest and maxillary incisal display during smile was normal (Figure 1). Intraoral examination revealed a healthy periodontium with moderate risk of caries. The upper dental midline was deviated 1mm to the right of the facial midline (Figure 2). The space analysis showed 5mm crowding in the upper arch and 3mm crowding in the lower arch. Dentally, he presented with half-cusp class II molar and canine relationship, 5mm overbite and 3mm overjet (Figure 2). Cephalometric measurements showed a class II skeletal pattern with a normal maxilla (SNA angle=81) and a retrognathic mandible (SNB angle=76). Wit's value was 6 mm that supports class II jaw discrepancy (Figure 3). Vertical measurements showed a mild high-angle vertical pattern. Upper and lower dental analysis revealed retroclination of upper incisors and slight proclination of lower incisors. The panoramic radiography showed impacted lower third molars. Some caries lesions were observed. The form

Figure 2: Case 1, pretreatment intraoral photographs

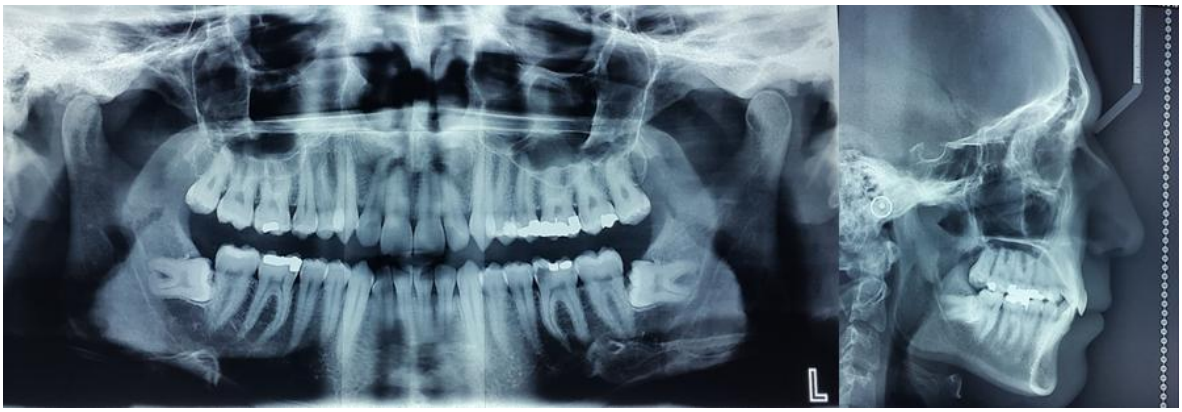

Figure 3: Case 1, pretreatment panoramic and lateral cephalometric films

and length of roots appeared normal and no periodontal defects were detected (Figure 3).

The aim of our camouflage treatment was to improve patient's function and esthetics by elimination of maxillary and mandibular crowding, correction of deep bite and midline discrepancy, and achieving class I dental relationship. To accomplish these goals, extraction of upper first premolars and lower second premolars were planned. Maximum anchorage mechanics using transpalatal arch was considered for the upper arch.

After the extraction of premolars, upper and lower arches were bonded with 0.018 slots, standard edgewise brackets (Dentaurum; Ispringen, Germany). Alignment and leveling was achieved using 0.014 and 0.016 Ni-Ti wires (Dentaurum; Ispringen, Germany). After leveling phase was completed, 0.016 stainless steel wire (Dentaurum; Ispringen, Germany) was placed and canine distalization started. One side of the upper arch was randomly chosen for the piezopuncture procedure and the other side underwent conventional canine retraction. The proposed surgical procedure was fully explained to the patient and he signed an informed consent.

The surgical procedure was started by infiltrating local anesthesia to mesial and distal sides of upper canine. Afterwards, we used a piezosurgical tool with a sharp insert tip (OT7; Mectron, Carasco, Italy) to perform the cortical punctures through the gingiva (Figure 4).

The depth of punctures was 3 mm in the cortical bone, by holding the instrument tip perpendicular to the gingiva for 5 seconds under saline solution irrigation (Figure 5). A total of 24 punctures were made on

Figure 4: The piezosurgical tool used in this study

Figure 5: Cortical punctures in the buccal and palatal aspects of canine

the mesiobuccal, distobuccal, mesiolingual and distolingual sides of the upper canine root. The patient was recommended to use 0.2% chlorhexidine mouthwash twice a day for the first week after the operation and continue the routine tooth brushing during the postoperative period.

Canine distalization was performed as soon as possible after the surgery to take advantage of the regional acceleratory phenomenon induced by cortical injury. Ni-Ti closed coil springs (G&H Wire Co., Indiana, USA) on 0.016 stainless steel wire (Dentaurum, Ispringen, Germany) were used to apply 150gr-retraction forces to maxillary canines on both sides (Figure 6).

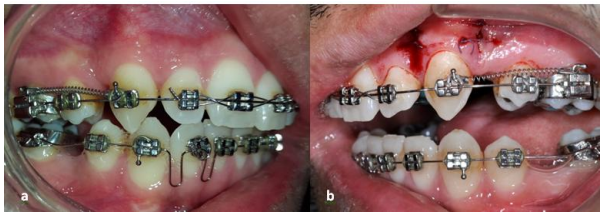

Figure 6: Closed Ni-Ti coil spring stretched between the canine and the first molar. A, control side; B, piezopuncture side

The retraction force was measured using a strain gauge (Dentaurum; Ispringen, Germany) and the force was readjusted at each monthly visit.

The amount of canine distalization (the distance between the distal aspect of lateral incisor and the mesial contact point of canine, as well as the distal aspect of canine to the mesial contact point of second premolar) and canine rotation (the angle between the median palatal raphe and the line through the mesial and distal edges of canine) were measured . These measurements were performed on the scanned pictures of stone models using the smile analyzer software [20] at the beginning (T0) and the end of first (T1) and second month (T2) after operation. In addition, the casts were used to assess the degree of canine mesiodistal tipping using a tooth inclination protractor (Figure 7).

Figure 7: Tooth inclination protractor used for assessment of canine tipping

The amount of molar mesial movement (anchorage loss) was measured on dental casts using a transferable acrylic removable appliance that was made on the initial model including a Nance-type button and 0.8 mm SS wires extending to the central fossa of first molars (Figure 8).

Immediately after surgery, the patient showed a little discomfort on the operation side, yet no pain was reported at the follow up visits. There were no symptoms of edema and inflammation. Two months after the surgery, the amount of distal crown movement of upper canine was 1.52 mm on the operation side and 0.87 mm on the control side. The observed mesial movements of first permanent molars on the operation and control sides were 0.13mm and 0.24mm, respectively. In addition, the degree of canine distal rotation observed was 2˚ on the control side and 10˚ on the operation side. Both right and left upper canines showed 2˚ distal tipping.

Figure 8: Transferable removable appliance with reference wires used to measure the amount of anchorage loss

Case Report 2

A 17-year-old female patient referred to the orthodontic clinic of Mashhad University of Medical Sciences with chief complaint of upper and lower anterior crowding. Routine diagnostic evaluations including impressions, intraoral and facial photographs, panoramic and lateral cephalometric tracing were performed. Upon examination, the patient showed a symmetric face and a slightly convex profile with normal vertical facial height. The lips were competent at rest and no gingival display was observed on posed smile (Figure 9). The upper dental midline was coincident to the facial midline and the lower dental midline was deviated 2 mm to the right. Anterior crowding was present in both arches (8mm for maxilla and 7mm for mandible).

Dentally, she presented with half-cusp class II canine and molar relationship on the right side, 5mm overjet, and 3mm overbite (Figure 10). Cephalometric measurements showed a class II skeletal pattern (Wit's appraisal=2 mm) with mild maxillary protrusion (SNA angle=85˚, SNB angle=80˚) (Figure 11). Skeletal verti-

Figure 9: Case 2, pretreatment extraoral photographs

cal measurements showed a slightly hypo-divergent pattern. Dental analysis revealed proclination of both upper and lower incisors. Unerupted third molars and some caries lesions were observed on the panoramic radiograph (Figure 11).

The goal of our treatment was to improve patient's function and esthetics by elimination of maxillary and mandibular crowding, correction of midline discrepancy, and achieving class I dental relationship. To bring about these goals, extraction of upper and lower first premolars was planned with maximum anchorage mechanics for the upper arch.

The same orthodontic protocol and mechanics were used as in first case to achieve ideal post treatment results. Initial alignment and leveling stage took place over the first 3 months of treatment using 0.014 and 0.016 Ni-Ti wires. Thereafter, canine retraction phase was performed using Ni-Ti closed coil springs on 0.016 stainless steel wire. One side of the upper arch was randomly chosen for the piezopuncture technique and the surgical procedure was fully explained to the patient. A written consent was obtained from the patient.

The same piezopuncture procedure was applied as in first case, to develop cortical punctures through the gingiva on the mesiobuccal, distobuccal, mesiolingual, and distolingual sides of the upper canine. No swelling or major discomfort was associated with this technique. After the surgery, canine distalization was started as soon as possible to take advantage of the regional acceleratory phenomenon induced by cortical punctures (Figure 12).

Plaster models were obtained at each follow up visit (i.e. first and second month after operation) and measurements of canine distal movement, anchorage loss, canine rotation, and tipping were accomplished. At two months after surgery, the amount of distal crown movement of upper canine was 4.92mm on the operation side and 3.29mm on the control side. The observed mesial movements of first permanent molars on the operation and control sides were 0.94mm and 1.10mm, respectively. Upper left canine (control) sho-

Figure 10: Case 2, pretreatment intraoral photographs

Figure 11: Case 2, pretreatment panoramic and lateral cephalometric films

wed 1˚ and upper right canine (piezopuncture side) showed 2˚ distal tipping. Moreover, the degree of canine distal rotation observed was 3˚ on the control side and 10˚ on the piezopuncture side.

Discussion

Duration of treatment is an important factor for orthodontic patients, particularly for adults. In recent years, notable methods including rapid alveolar distraction and corticotomy-facilitated orthodontics have been developed to shorten the treatment period. [21-22] Although quite effective, corticotomy procedures are be very invasive and traumatic to patients. These techniques have some disadvantages including potential damage to bone and teeth, long surgical time, patient discomfort after surgery, subcutaneous hematoma of neck and face and possible marginal osteonecrosis. [23] Consequently, corticision, piezocision, and piezopuncture procedures were introduced as less invasive alternatives for the activation of cortical bone. [16, 19, 24-25] The newly developed supplemental procedure, piezopuncture, [19] eliminates the use of bone malleting and soft tissue incisions. Hence, this technique is simple for orthodontists and reduces the patient's discomfort during and after surgery.

The mechanism of piezopuncture is based on the biological concept of RAP. Garg [26] stated that RAP is primarily initiated by trauma to the cortical bone. The multiple piezoelectric punctures in the buccal cortical bone are able to produce a significant amount of osteoclastic activity and demineralization in the areas of tooth movement. The induced high bone turnover is restricted to the surgical areas and effective for the first two months. [24, 27] In an animal study conducted by Kim *et al.*, [19] piezopuncture accelerated the rate of tooth movement and the remodeling process of alveolar bone without causing any damage or side effects.

To our knowledge, the present case report is the first human study on the use of piezopuncture procedure to assist orthodontic tooth movement. Immediately after the piezopuncture surgery, continuous force of 150g was applied for canine distalization and the force was reactivated monthly. We achieved about 1.5mm distal crown movement in first case and near 5mm in second patient, after two months of canine retraction. More tooth movement was occurred in the first four weeks than the second month. The reason may be the transient nature of the RAP. [28] Therefore, a second piezopuncture surgery might accelerate tooth movemement after fourth week.

The depth of penetration into cortical bone with

Figure 12: Closed Ni-Ti coil spring stretched between the canine and the first molar. A, piezopuncture side; B, palatal view

the piezopuncture technique is 3mm, which is the least among the previously described methods of cortical activation for acceleration of tooth movement. In a study conducted by Abbas *et al.*, [29] comparing the effects of corticotomy and piezocision, the depth of bony penetration was considered equivalent to the feeling of cancellous bone. Aylikci *et al.*, [27] similar to Kesser *et al.* [30] and Brugnami *et al.*, [31] reported a penetration depth of 4mm into cortical bone during piezocision-assisted treatments. Furthermore, due to the elimination of vertical incisions and mucoperiostal flaps, less trauma and tissue damage occurs with the piezopuncture procedure. Although this may lead to less surgical time and less fear and discomfort for patient, the extent and duration of the RAP may not be sufficient for the entire canine distalization period or complete orthodontic treatment. Therefore, repeated procedures of piezopuncture at regular intervals might help to resolve this problem. Even so, the patient would be more comfortable compared with the more aggressive methods.

To assess the mesio-distal inclination of canine teeth relative to the occlusal plane, we used a manual technique with the tooth inclination protractor. [32] However, Abbas NH *et al.* [29] assessed the changes in canine inclination through cone-beam computed tomography scans taken before and at the end of canine retraction. In the present study, taking CBCT from canine teeth was unnecessary and ethically not justified.

Using piezopuncture technique, we found about 2˚ distal tipping of canine teeth over two months of canine retraction (almost similar to the control side). In a piezocision-assisted canine distalization study by Aylikci *et al.*, [27] authors reported about 4-8˚ distal tipping of teeth over 4-5 months of canine retraction. This was assumed as parallel movement. Tipping of canines could be affected by various factors. Results may depend on the applied force magnitude, size of stainless steel arch wire, and degree of distal crown movement.

In the present report of two cases, the degree of canine distopalatal rotation on the piezopuncture side was greater than the control side. Since the amount, duration and line of action of the retraction force were the same in both sides, the more canine rotation on the operation side the less resistance in the cortical bone prompted by the piezopuncture procedure. Therefore, canine may need more rebound time to rotate into the correct position. However, no statistical analysis was performed in the present study and future randomized clinical trials are required to assess the possible significant differences in canine rotation induced by the piezopuncture method.

Conclusion

This study applied a recently introduced supplemental procedure called piezopuncture to enhance orthodontic tooth movement in two extraction cases. It seems that using piezopuncture technique resulted in more distal crown movement of the canine on the operation side during the two-month period of retraction. Further studies with longer assessment periods and randomized clinical trials with repeated piezopunctures at regular intervals are recommended to investigate the therapeutic benefits of piezopuncture procedure in orthodontic tooth movement. In addition, more studies are suggested to explore the optimal power range of a piezosurgical tool to induce a degree of regional acceleratory phenomenon sufficient for reduction of treatment time.

Conflicts of Interest

The authors declare no conflicts of interest.

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